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High-Efficiency Transmission Gratings Fabricated in Bulk Fused Silica

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High power ultraviolet lasers are now widely used in the semiconductor industry and inertial confinement fusion research, and are finding increased application in medical therapy. Whether based on excimers or frequency converted solid-state, high power ultraviolet lasers continue to be plagued by issues of optical damage and a limited choice of optical components for beam manipulation. In particular, system performance is often limited by the damage threshold of cavity and transport mirrors. Beam transport and steering based on refractive optics are limited not by surface damage as is the case with reflective systems but instead by bulk damage induced by two photon absorption, color center formation and self-focusing. These limitations can, in principle, be overcome in many applications by the use of transmission gratings fabricated in high damage threshold, transparent materials.

We have designed and fabricated high-efficiency transmission gratings etched in bulk fused silica for use in ultraviolet high-power laser systems. By controlling the shape, depth, and duty cycle of the grooves we have achieved a diffraction efficiency exceeding 95% in the $m = -1$ order. By directly etching the grating profile in bulk fused silica, we have achieved damage threshold greater than 13 J/cm^2 for 1 nsec pulses at 351 nm. Our fabrication process, utilizing LLNL's 80-cm laser interference lithography exposure system and 40-cm chemically-assisted ion beam etcher, allows for production of large-aperture components. We will present the design and fabrication and discuss our experimental results.

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